BEST METHOD OF MASTERING A MOTOR PROBLEM

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The gaining of motor control constitutes a great part of the work of the schoolroom. Probably no more important development has been made in recent years than the recognition of the place of motor activity in the education and development of the child. As a result, the curriculum contains many studies in which the motor side of the adjustment primarily is emphasized. Not only is this manifested in such studies as penmanship, learning one's native language or a foreign tongue, etc., but especially in gymnastics, aesthetic dancing, typewriting, musical technique, manual training, and other shop activities. Yet there has been almost no attempt to make an analysis of the psychological factors involved in these several motor activities, with the exception, probably, of the handwriting case. Almost the sole work done upon motor learning as a general problem has been restricted to the question of the distribution of the learning effort. The recent publications of Murphy have been typical of all the conclusions, namely, that "better work for the amount of time expended can be done in our schools (both for hand manipulation and also for the so-called mental work) through a distribution [of the learning]."[1]

While the question of massed versus distributed learning effort is an important consideration for the motor problem, another and even more fundamental one challenges our attention. This is the problem of the method of learning. Specifically, is it better to master a complex motor problem as a whole or to divide the learning into separate tasks, master each unit, and then connect the several units in proper serial order? This is the familiar problem of verbatim learning, where the conclusions have been definitely

[1] H. H. Murphy, "Distribution of Practice Periods in Learning," *Journal of Educational Psychology*, VII (1916), 150–62. (See bibliography.)

stated, namely, that the "whole" method is far superior to the "part" method, for the mastery of both logical and rote material. But this historic problem has never been tested out in the motor field. This paper is the result of such an attempt.

For the basis of the test, the maze was chosen. Several reasons supported this selection. First, the pencil maze (which the subject learns without the aid of vision but by means of the tactual-kinaesthetic sensitivities) constitutes a problem whose general nature is easily understood, yet which requires many trials and high expenditure of learning effort for its final mastery. Second, the errors and successes made in the several learning trials can be measured with absolute accuracy. Third, the maze area can be duplicated for animal learning and a sound bit of comparative work hereby rendered possible. (In this connection, it may be remarked that the facts of animal learning have great significance for the prediction and control of human behavior, and that the experimental educators can well afford to study some problems of learning from this comparative viewpoint.) Fourth, the maze problem is highly serviceable for whole-part testing. The accompanying diagram shows this. In the maze under discussion, there are four distinct maze areas (Fig. 1), each having entrances and exits at a common center, each possessing the same number and type of cul-de-sacs, the same length of true pathway, and, by the mere removal of sliding panels, all capable of being connected without any linear waste. Consequently, this maze could be learned or run as a whole, in parts, or in any desired combination of parts. It is hereby strictly comparable to a four-stanza poem or to a nonsensical series of definite length and number of syllables.

As subjects for human testing, students from the introductory psychology classes were used. Each subject was assigned some particular learning method and given two trials a day until the maze area was mastered. Rats were the animals employed. The number of trials per day, etc., was the same as in the human situation. In all cases each run was numbered and timed, and three types of errors recorded—cul-de-sacs entered while going forward, while returning toward the entrance, and the number of sections of the true pathway traversed while returning toward the closed

entrance. These errors appear in the records as types A, B, and C respectively.

Taking one's cue from the results secured for verbatim learning, it is not surprising that the "whole" method proves far more efficient than the "pure part" method in the motor realm, especially

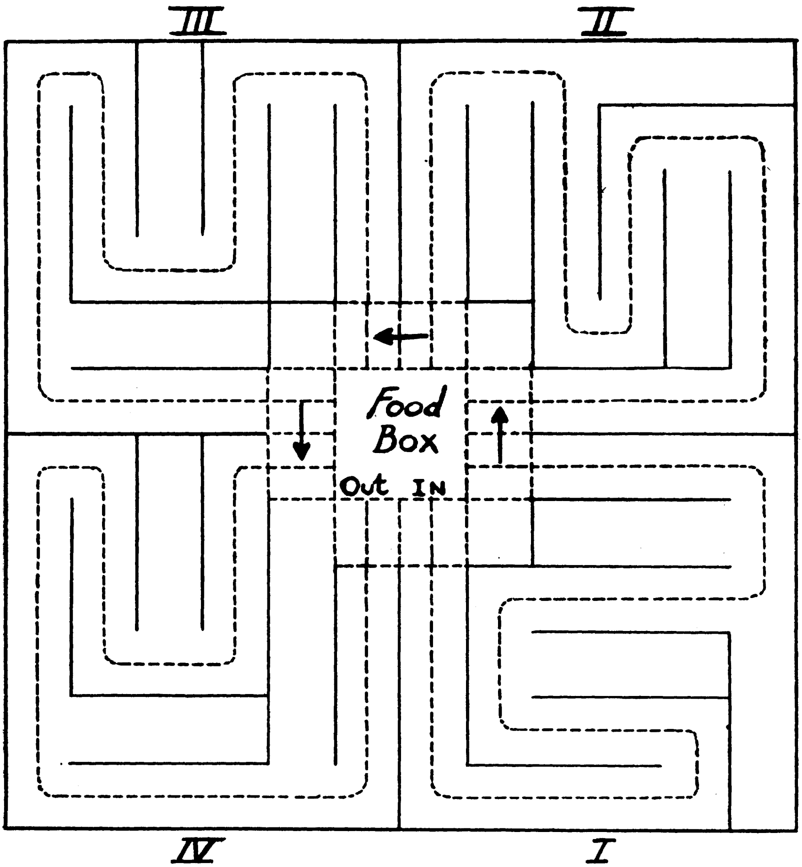

FIG. 1.—A maze for testing learning by whole and part methods. Each of the four sections has an independent entrance and exit at the common center. The course of the true pathway is represented by a dotted running line. Dotted lines across the passageway represent removable panels. By means of these, it was possible to so arrange the areas that the maze could be learned as a whole; in parts later connected; forward or backward, etc. The rectangular areas around the center form a distributing gallery, by means of which the runner might pass from one section to another not adjacent, e.g., I–III.

when no more retracing is allowed than is possible in part learning. For the humans there is an advantage in percentage terms of 26, 126, and 193 per cent, respectively, for the number of trials, time, and errors. In the case of the rats there is no advantage for the number of trials, but there are very significant figures of 13 and 44 per cent respectively for time and errors.

Time does not permit an extensive report of the behavior of the learners. It is necessary to state, however, that the weaknesses of the "pure part" method are not assignable to conditions operating during the learning of the four separate sections. Rather, they are assignable wholly to the numerous trials required for the connection of the separately learned parts. Confusion, hesitation, retracing, random activity, etc., characterize these acts of connection. The disturbing agencies here are the break-up of those factors of place association which have been established in the earlier learning of the four units. These positional factors are both temporal and spatial. Short time-spans come to mean the solving of the short problem. Short distance traversed comes to mean the cessation of the running activity. Moreover, each turn, cul-de-sac, particularly difficult place, etc., becomes located just as definitely in the temporal and spatial series as a certain syllable does in a nonsensical series. In the final act of connecting the various motor units, however, all these positional establishments that meant success under unit conditions now, even when satisfied, fail to bring the looked-for results. Their break-up is demanded before the entire maze can be run perfectly.

The proof of these assertions is mainly experimental. The question to be answered is as follows: If the weakness of "part" learning is assignable to the act of connection, cannot this act of connection be so controlled as to produce results that are superior to those of the "pure part" method, and which consequently approach those of the "whole" method as a limit? Three modifications of the "pure part" method are here reported. The "progressive part" method calls for the mastery of sections I and II as separate problems, these areas then being connected into a unit series as soon as section II is learned. Section III is learned as a unit and added to the I–II unity just established. Section IV,

learned and then added, completes the tuition. This method differs from the "pure part" method not in so far as regards learning all the sections as units but in that each part is joined to the earlier parts as soon as learned. This calls for the break-up of the

TABLE IA

WHOLE AND PART METHODS IN MAZE LEARNING

Tables to show the average of human and rat groups in learning a maze by whole or part methods. The first whole method permits unlimited returning; the second allows no more retracing than is normally possible in the "pure part" method. The various part methods differ regarding the time and manner of the act of connection.

Method	Humans			Errors			
	No. of Individuals	Trials	Time in Seconds	A	B	C	Total
Whole							
Returns allowed......	6	12	641	16	13	97	126
Returns prevented....	6	17	541	23	6	52	81
Part							
Pure part	6	23	1,220	36	25	176	237
Progressive..........	6	10	352	10	3	44	57
Direct repetitive......	6	11	618	15	11	70	96
Reversed repetitive....	6	22	1,014	27	24	175	226

TABLE IB

Method	Rats			Errors			
	No. of Individuals	Trials	Time in Seconds	A	B	C	Total
Whole							
Returns allowed	12	27	4,174	54	24	139	217
Returns prevented....	9	30	1,666	56	4	51	111
Part							
Pure part............	9	30	1,907	74	17	108	199
Progressive..........	9	11	662	39	2	24	65
Direct repetitive......	11	21	1,442	45	9	88	142
Reversed repetitive ...	8	17	882	22	5	49	76

positional establishments when these are few in number and not deeply intrenched. A second method is the "direct repetitive." This calls for the mastery of section I, and then a review of section I as leading into section II. This is continued until the I–II area is mastered. In turn, the united I–II area is repeated in each trial

when section III is being mastered, and the I–III unity in conjunction with the mastery of section IV. This method not only reviews the earlier learned units but, better, it calls for the disruption of the positional establishments a short time after they are once formed. The third method is the "reversed repetitive." Herein section IV is learned as a unit and the runner then started upon section III, ending each trial with the running of the previously learned section IV. When the III–IV area is completed, Section II is added as the new element of the enlarging motor series. Section I, together with the steady review of all the subsequent areas, completes the learning. Both of these "repetitive part" methods satisfy the demands of any part method. Both have strength, as does the "progressive part" method, in that they negate the influence of those place associations which are the injurious by-products of all learning of this type.

The scores of these "modified part" methods are highly significant. They are naturally far superior to those of the "pure part" method, but the surprising feature consists in the fact that the results of the methods do not merely approach "whole" method scores but rather they far excel them. The data warrant but one conclusion. *If the act of connection is controlled, the weaknesses of the "part" method are so negated that the part procedure is preferable to the whole.* This is not the entire story, but it is the major part of it. The rest is that any "part" method has certain inherent advantages, which cannot be treated with any satisfaction in this paper. These inherent advantages, taken in conjunction with the progressive and distributive handling furnished the positional factors, go a long way in explaining the superiority of such "part" methods as are herein discussed. It seems rational to assert, therefore, that some form of the "part" method, and preferably the "progressive part," should be selected when a motor habit is to be established.

The writer is aware that his conclusions contradict the findings for verbatim learning. Several explanations are possible. His results may be inaccurate, and hence not true for the motor field. Or, perhaps the same results would not maintain upon the motor and the so-called ideational levels. To the first of these possibilities

the writer cannot agree. The second only invites speculation, because there are too few experimental data. Rather, the writer would suggest that these "modified part" methods need to be tried out in the fields of verbatim learning and there found inferior, before the wholesale[1] acquiescence to present results is continued.

[1] Results in verbatim learning, published by Professor Freeman in his *Experimental Education* (Houghton Mifflin Co., 1916), pp. 67–70, strengthen the suggestion.